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### Five hundred and thirty-ninth Meeting.

September 20, 1864. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

Professor Lovering, from the Committee of Publication, reported that the price of the Memoirs of the Academy had been fixed at eight dollars per volume, and the price of the Proceedings at two dollars per volume; members being provided with copies, according to a standing vote, at half these prices.

Mr. Bowditch reported from the Committee of Finance a recommendation to raise the salary of the Assistant Librarian to six hundred dollars; and this recommendation was adopted.

A list of the duplicates in the Library, prepared by the Assistant Librarian, was referred to the Committee on the Library, with powers to effect exchanges.

Mr. George Livermore was elected Treasurer of the Academy, in place of Mr. Wigglesworth, resigned; and on the motion of Mr. Bowditch, the following vote was passed: —

"Whereas, Edward Wigglesworth, Esq. has been compelled by ill-health to resign the office of Treasurer of the Academy, — *Voted*, that the Auditing Committee, Messrs. T. T. Bouvé and Dr. Ware, be instructed to audit his accounts and receive from him the property of the Academy which he has in charge, and give him their receipt for the same, and deliver said property to his successor.

On the motion of Mr. E. C. Cabot, it was voted that the thanks of the American Academy be expressed to Mr. Wigglesworth for his services as Treasurer, and that the Fellows deeply regret the ill-health which has rendered his withdrawal from the office necessary.

Professor Winlock made the following communication: —

"I wish to call the attention of the Academy for a moment to a paper read at a recent meeting, on the Right Ascension of the Pole Star. This paper contained a criticism on the investigation from which is derived the mean place of this star used in the computations of the American Nautical Almanac, and a statement that the elements there used are erroneous.

It is not my intention to enter upon any extended examination of this paper, on which Mr. Safford seems to have bestowed much labor, nor, at present, to express any opinion upon the justness of his criticism or the correctness of his conclusions; but simply to call attention to the magnitude of the error which he claims to have detected, and to show to what extent the usefulness of the Nautical Almanac has been impaired by the alleged error, if Mr. Safford is right.

I am led to do this by the apprehension that the impression may have been given that some serious injury has been done to the public service by the use of an erroneous value of the place of this star on the part of the Coast Survey, the National Observatory, and the Nautical Almanac, — or that there is some culpable and important uncertainty about a fundamental element in astronomy. This apprehension is justified by the fact that it has since been published in pamphlet form, with a preface by Professor Bond, in which Professor Bond states that this matter is of moment to American astronomers, because the alleged erroneous value of the mean R. A. of the Pole Star has been adopted by the public institutions above mentioned.

Mr. Safford treats of the use of the Almanac place as leading to errors of *prediction*, and presents the nearer fulfilment of his predictions as confirmation of the superiority of his determination of the element in question. The phenomenon *predicted* is the appearance of the Pole Star on the meridian. Now to form a distinct idea of the consequence of the use of false data we must examine its effect on this appearance.

The motion of the Pole Star is so slow, in consequence of its proximity to the pole, that an error of time in a *prediction* which would be quite considerable in some questions in astronomy would here correspond to a very small change of place of the star, or a very slight difference in the appearance to the observer. Thus a second of time would only correspond to a change of position amounting to about one third of a second of space. We will now consider how small a quantity a second of space is. The following illustration will place it before the mind quite distinctly. If a human hair supposed to measure $\frac{1}{200}$ of an inch in diameter were placed at the distance of 86 feet from the eye, its thickness would subtend an angle at the eye of $1''$, and would shut out just that amount of celestial space.

If now we compare the prediction of a transit of Polaris made from

Mr. Safford's mean place with one made from that used in the Nautical Almanac, at the epoch of Dr. Gould's computations, the beginning of the year 1855, and call Mr. Safford's the true and the other the fictitious Pole Star, the interval elapsed between the transits of the two stars would be $0^s.64$, and the space between them would be $0''.2363$, which would represent the difference between the two predictions as it would appear to the eye of the observer. Now a hair of the dimensions above given, placed at the distance of 364 feet from the observer, would entirely cover this space, while the same hair, removed to nearly twice this distance, or 665 feet, would cover the space between Gould's Pole Star and Bessel's at the same epoch. If we make the comparison for a date ten years later, the beginning of the year 1865, near the epoch of Mr. Safford's computation, made with the additional data obtained in ten years, we find that the difference in the times of prediction between Mr. Safford and the Almanac would be about one second of time, and the distance apart of the two stars about one third of a second of arc, which would be completely occulted by a hair at the distance of 233 feet.

Now if we compare the American Ephemeris place with the British Almanac place for the beginning of the year 1865, which latter place I believe was deduced by Mr. Adams, we find the difference between the times of prediction to be $0^s.47$, and the difference of the phenomena, $0''.17$, would be entirely shut out of view by a hair at the distance of 495 feet. Or if there were five Pole Stars that should come to the meridian at the different times corresponding to the predictions of Safford, Bessel, Adams, the American Nautical Almanac, and the Berlin Jahrbuch respectively, no meridian instrument with which the Pole Star was ever observed would separate the components of the multiple star which they would form. And if there were two Pole Stars, one in the place assigned by the British Almanac, and the other in that fixed by the American Ephemeris, they would not be separated by any telescope in existence. If they were reduced to the 10th or 11th magnitude, and all circumstances were favorable, and Mr. Clark's great 18-inch glass were used by Mr. Clark himself as the observer, they could not *possibly* be separated; and the same is true of the Berlin Jahrbuch place. It will thus appear that for all the purposes for which a Nautical Almanac is designed, or for which the Coast Survey may use a star, the place adopted will be found sufficiently near the truth for the present. This star is one of a catalogue of two hundred stars prepared for the use of the

United States Coast Survey, and which has been adopted by the Nautical Almanac. They seemed well selected, their places were derived from observations up to 1851 by an American astronomer entitled to confidence, the investigations were published in detail, open to criticism, and inviting it, thus satisfying all the conditions of a safe catalogue to be adopted by the Nautical Almanac. It was expected that the places would be improved from time to time by the aid of later observations, but I can see nothing in the paper of Mr. Safford, in which he uses the additional observations of the last ten years, to convince me that the place of this star should now be changed from that adopted. And certainly the necessity of such a minute change cannot be considered as demonstrated. There are so many nice points in the combination of the work of different observers and different instruments, and so much is arbitrary, or dependent on the judgment of the computer, that the existence of a magnitude which is less than the personal equations of the observers, especially when it is not visible with the aid of the instruments employed, is extremely difficult to prove, and it is much more difficult to measure such a magnitude. In fact, the accuracy that appears to be reached by such a combination of observations by the method of least squares is often illusory, and is over-estimated by many astronomers. I doubt the possibility of measuring with any degree of accuracy a quantity which cannot be distinguished from zero by the sense employed in measuring it. The limit of exactness of measuring must lie very near the limit of distinct perception, and no repetition of observations can carry our knowledge much beyond it; and if, in the record of observations, a show of precision is kept up beyond this limit, nothing is added to the probability of the resulting value, but the reverse. This is not inconsistent with the doctrine of probabilities embodied in the method of least squares. The rigorous theory assumes continuity of error; and it also implies that in each observation there is some tendency or attraction toward the true value sought. Now this effect or attraction of the thing observed can only be operative within the limit of sensibility, and that part of each observation which is under this limit, and which we cannot know to be produced or influenced in some way by the object observed, might as well be appended arbitrarily or by the cast of a die. To expect to add anything to our knowledge by taking the mean of these would be hoping to coin pure ignorance into knowledge by the method of least squares.

And furthermore it is obvious from these considerations, and from the failure of the continuity of error, that the distribution of errors in accordance with the law prescribed by theory must fail unless they are counted within limits which include the limit of sensibility.

I do not wish to be understood in these remarks as under-estimating the value of such investigations as these on the Pole Star, or the usefulness of repeated attempts to reach the utmost limits of refinement attainable by computation, nor as depreciating the importance of watchful criticism of one another on the part of astronomers. But, as I have said, I was apprehensive that some who are not astronomers, from the circumstances attending the publication of Mr. Safford's paper, might attach to his correction of the place of the Pole Star a *practical* importance which I think Mr. Safford himself would not claim for it, and might needlessly fear that the Nautical Almanac, the Coast Survey, and the National Observatory had suffered injury from the use of an erroneous element.

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### **Five hundred and fortieth Meeting.**

### October 11, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

Dr. Pickering made the following communication: —

"After finding the names of lunar months in 1 Kings vi. 1 to 38, and viii. 2 (Chron. Obs. on Animals and Plants, p. 165), I was led to suspect that one of the measures of Jeroboam to prevent the reunion of the Hebrew people was the introduction of the Lunar calendar.

" Commencing a calculation by this calendar, I found in the death of the king of Israel and the king of Judah, both by the hand of Jehu, the seeming discrepance of three years in the Bible reduced to B. C. 877 y. $357\frac{5}{36}$ d. — 877 y. $317\frac{344}{360}$ d. = less than forty days.

" Continuing the calculation until the capture of Jerusalem by Jehoash, I found that King Amaziah was permitted to live after this event 'fifteen years' = half the so-called Muslim cycle, 'thirty years of twelve lunations = 10,631 days.' I was further surprised at finding that this half did not leave a fractional day, = 14 Julian years 202 days. A further reduction being even possible, $7\frac{1}{2}$ lunar years or ninety lunations = 7 Julian years 101 days.

" Here then was the means of substituting one calendar for another without interrupting a reckoning in lunations. And in Eastern coun-